

Safe Working Practices for Center 1100

Part A: PHS Information

PHS Identification

PHS-SNL06A00448-005 CINT (clean room, all labs) - Integration Lab

Hazard Classification: LOW

NEPA: SNA07-0202 CINT Integration Laboratories (1501, 1504, 1523, 1525, 1527 and 1532); SNA08-0179 CINT room 1511 - Integration Lab Parts Clean room

This completed SWP meets the requirements of a Job Safety Assessment as specified by the Work Planning and Controls manual.

Laboratory Owner

John Nogan, 1132, 284-8863

Brief Description of R&D Work Performed in this Laboratory

The integration wing of the CINT Core facility is a clean room where the bay is class 1000 and the chases, gowning room (1508), and parts clean room (1511) are class 10,000. The operations in the clean room are focused on micro- and nano-fabrication of devices for the study and development of nano-technology. These processes include, but are not limited to, wet and dry etching of Si and GaAs, physical vapor deposition, chemical vapor deposition, atomic layer deposition of metal, dielectric and semiconductors, contact mask photo-lithography, electro-beam lithography, and focus ion beam machining. These processes will require the use of both gaseous and liquid hazardous chemicals that are typically used in microfabrication.

Part B: Operations Identification, Hazards and Mitigation

Short Title of Laboratory Operations Category: Chemical Usage

Rigor Level: Low

Description of Laboratory-Specific Operations that Involves Chemical Hazards:

Acids: Sulfuric, Hydrochloric, Hydrofluoric, Phosphoric, Acetic, Citric, Perchloric, Buffered Oxide Etch and Nitric Acids are used for cleaning and etching.

Bases: Ammonium Hydroxide, Tetramethylammoniumhydroxide, Potassium Hydroxide, Sodium Hydroxide and polymers, III-V compounds (GaAs) silicon and aluminum.

Oxidizers: Hydrogen Peroxide and Ceric Ammonium Nitrate are used to form chemistries that can aid in the cleaning and etching of samples and surfaces.

Solvents: Positive/Negative Photoresist, Acetone, Toluene, Isopropanol, ethyl alcohol and methanol in addition to other typical Volatile Organic Compounds are used for semiconductor device fabrication.

Compressed gases: Nitrogen (N₂) is routinely used for electrical enclosure pressurization and for sample processing. Carbon Dioxide (CO₂) can be injected into specific wet sink rinse baths to protect sensitive materials from the corrosive affects of de-ionized water.

Local exhaust ventilation (LEV) is used for exhausting fume hood effluents, in accordance with LEV guidelines and monitored through the LEV inventory control program. Air discharges are small and consistent with typical R&D operations.

Baseline Occupational Exposure Assessments were completed and are listed below:

ER2007-2552 - Lab 1504

ER2007-2559 - Lab 1501

ER2007-2646 - Lab 1522

ER2007-2630 - Lab 1525

Conclusions stated that exposure controls are adequate for laboratory operations.

All activities that involve chemicals will follow the laboratory practices outlined in Center SOP1100.00 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories.

Applicable Technical Work Documents:

- SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories
- OP1100.189 Operating Procedure for Toxic/Pyrophoric/Inert Gas Cylinders Change-Out
- OP1100.009 Acid, Bases, & Solvent Wet Stations
- OP1100.206 Laser Mask Writer
- OP1100.209 OAI 800 MBA Mask Aligner, IL Lab
- OP1100.210 Suss MJB3 Mask Aligner, IL Lab
- OP1100.211 EG-2 Ebeam Deposition System, IL Lab
- OP1100.212 Jipelec Jetfirst 150 RTA, IL Lab
- OP1100.213 Trion Minilock III and Orion III Etch/Dep Systems, IL Lab

These documents are required reading for all authorized workers.

Possible Chemical Hazards:

- Acids & Bases
- Corrosive

Required Training:

- ESH100 ES&H Awareness
- LAB100 Laboratory Standard Information and Training
- LAB103 Site-Specific Laboratory Safety Training
- ENV112 Hazardous Waste and Environmental Management
- ILUA100 CINT Integrated Lab Unescorted Access
- CINT100 Center for Integrated Nanotechnologies Site Specific Training
- MED105HF Hydrofluoric Acid Safety

These courses are required training for all authorized workers.

Mitigation of Chemical Hazards:

Safety goggles, to-the-elbow nitrile gloves, and a chemical resistant long sleeved lab coat are worn while

<ul style="list-style-type: none"> • Toxic • Caustic 	<p>handling both acids and bases. Acids and bases are marked and stored separately in secondary containment. Solvents are stored in an approved flammable cabinet. Other hazardous liquids are stored in the appropriate manner per SOP1100.001. A minimum of latex gloves and safety glasses are worn while handling hazardous liquids to mitigate incidental contact and are handled in both the fume hood and wet benches.</p>
<ul style="list-style-type: none"> • Solvents & Liquid Chemicals • Flammable • Carcinogen 	<p>To mitigate incidental contact, all chemicals are handled with basic PPE (latex gloves and safety glasses) and always either in a fume hood or wet bench. Additional PPE (specific chemical resistant gloves, lab coat and safety goggles) is utilized based on the chemical hazard as per the chemical MSDS and SOP1100.001. All hazardous waste is disposed of in accordance with SOP1100.001.</p>

Short Title of Laboratory Operations Category: Toxic Gases Rigor Level: Low	
Description of Laboratory Operations Category: <i>Toxic Gases:</i> The four toxic gases used in the clean room are silane (8 lbs), dichlorosilane (8lbs), ammonia (8 lbs cumulative), boron trichloride and chlorine (each < 1 lb).	
Applicable Technical Work Documents: <ul style="list-style-type: none"> • SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories • OP1100.189 Operating Procedure for Toxic/Pyrophoric/Inert Gas Cylinders Change-Out 	Required Training: <ul style="list-style-type: none"> • See above under chemical hazards
These documents are required reading for all authorized workers.	These courses are required training for all authorized workers.
Resulting Hazards: <ul style="list-style-type: none"> • Toxic Gases <ul style="list-style-type: none"> ➢ Silane ➢ Boron Trichloride ➢ Ammonia ➢ Chlorine ➢ Dichlorosilane 	Mitigation of Identified Hazards: <p>Toxic Gases are contained in gas cabinets designed to shut down upon detection of any leaks. A high level alarm will activate upon the detection of a leak at 3 times the Threshold Limit Value. This notification alerts personnel to evacuate the building. Personnel receive site specific training for integration laboratory activities and have been briefed on the hazards and what to do in case of an emergency.</p>
	<p>The Toxic Gas Monitoring System (TGMS) system is comprised of a decentralized Life Safety Network based on the LonWorks Technology with intelligent network nodes. The digitally networked input/output devices will notify personnel and shut down equipment based on a program customized for the requirements of the CINT Integration Labs. Network devices include Honeywell (MST Technology) Satellite FTT gas monitors, Echelon</p>

	digital interface modules, bus monitors, a Local Information Display and DVS (Data Visualization System). Output devices include beacons/horns, relay shut down of gases and signals to the Sandia Fire Protection panel for notification to the Sandia Emergency Operation Center.
	During gas cylinder change-outs, Self Contained Breathing Appartus (SCBA) will be worn by trained personnel.

Short Title of Laboratory Operations Category: Pressure System Operations	
Rigor Level: Low	
Description of Laboratory Operations Category: Non-Toxic compressed gas processes delivery systems currently in use include: Nitrogen (N ₂), Argon (Ar), 5% Helium/Argon Balance (5% He/Ar), Oxygen (O ₂), Helium (He), 5% Hydrogen/Nitrogen Balance (5% H ₂ /N ₂), Nitrous Oxide (N ₂ O), Carbon Dioxide (CO ₂), Sulfur Hexafluoride (SF ₆), Trifluoromethane (CHF ₃), Tetrafluoromethane (CF ₄), Octafluoromethane (C ₄ F ₈).	
Applicable Technical Work Documents: <ul style="list-style-type: none"> • Equipment manuals. • Pressure Safety Data Packages 	Required Training: <ul style="list-style-type: none"> • PRS150 Pressure Safety Orientation (All operators) • PRS250 Advanced Pressure Safety (Installers only) • PRS115 Cryogen Safety
These documents are required reading for all authorized workers.	These courses are required training for all authorized workers.
Resulting Hazards: <ul style="list-style-type: none"> • Explosion • Asphyxiation • Bodily injury • Eye injury 	Mitigation of Identified Hazards: All procedures are done in accordance with guidelines in the Pressure Safety Manual. Gas cylinders are kept chained and are equipped with pressure relief valves (PRVs). All pressurized systems or tubing networks are regulated by approved gas-specific pressure regulators and are fit with PRVs. All effluent lines are exhausted to the fume hood to mitigate an asphyxiation hazard. Safety glasses are worn at all times when dealing with pressurized systems. The facility gas panels or cabinets are equipped with pressure relief valves or pressure sensors as specified by Sandia safety procedures.

Short Title of Laboratory Operations Category: Environmental	
Rigor Level: Low	
Description of Laboratory Operations Category: Solid as well as liquid hazardous waste is generated during operation processes.	
Applicable Technical Work Documents: <ul style="list-style-type: none"> • SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories 	Required Training: <ul style="list-style-type: none"> • LAB100 Laboratory Standard Information and Training • LAB103 Site-Specific Laboratory Safety Training • ENV112 Hazardous Waste and Environmental Management.
These documents are required reading for all	These courses are required training for all

authorized workers.	authorized workers.
Resulting Hazards: <ul style="list-style-type: none"> • Bodily injury • Environmental Concern 	Mitigation of Identified Hazards: Acid contaminated wipes, swabs, gloves and other solid materials will be disposed of in the waste receptacles marked Acid. Solvent contaminated wipes, swabs, and gloves will be disposed of in the trash receptacles marked Solvent. Dried wipes of evaporated acetone, isopropanol, or methanol may be disposed of in the non-hazardous trash. Base contaminated wipes, swabs, gloves and other solid material will be disposed of in the trash receptacles marked Base Waste Only. Liquid Acid Waste - Small quantities of concentrated acids are dumped into the wet station and then travel to a neutralization system before discharging into the sanitary sewer systems. Exhaust from the chlorine ICP and CVD ICP reactor vacuum pumps go through a dynamic oxidation abatement unit before being introduced to the CINT exhaust system prior to being exhausted into the atmosphere.

Short Title of Laboratory Operations Category: Thermal hazards Rigor Level: Low	
Description of Laboratory Operations Category: Internal surfaces of the ICP and RTA systems and the substrates may become heated during operation. Personnel also occasionally will utilize liquid nitrogen for experiments/research operations.	
Applicable Technical Work Documents: <ul style="list-style-type: none"> • Equipment manuals. • Pressure Safety Data Packages 	Required Training: <ul style="list-style-type: none"> • PRS115 Cryogen Safety (as applicable)
These documents are required reading for all authorized workers.	These courses are required training for all authorized workers.
Resulting Hazards: <ul style="list-style-type: none"> • Thermal burns 	Mitigation of Identified Hazards: Users take appropriate precautions while working with this equipment. Combustible materials are controlled in the vicinity of hot surfaces. Substrates must be handled with tweezers or vacuum wand. The platen or carrier may also be quite hot and must be handled with tweezers or high temperature gloves and a sign indicating hot surfaces are present when the ICP reactor is operated under conditions that produce substantial platen heating. The exterior of the equipment does not become hot.

For additional lab-specific operations that involve other hazards copy, paste, and complete the cells above as needed.

Short Title of Laboratory Operations Category: Equipment Maintenance Rigor Level: Low	
Description of Laboratory Operations Category: Vacuum chamber servicing, mechanical and electrical component troubleshooting and replacement.	
Applicable Technical Work Documents: <ul style="list-style-type: none"> • Equipment Manuals. • Equipment Operating Procedures. • Pressure Safety Data Packages • SOP1100.001 Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100 Laboratories <p>These documents are required reading for all authorized "maintenance" workers.</p>	Required Training: <ul style="list-style-type: none"> • PRS115 Cryogen Safety (as applicable) • PRS150 Pressure Safety Orientation • PRS250 Advanced Pressure Safety • LTO210 Lockout/Tagout for Authorized Workers • LTO220 Annual lockout/tagout roles and responsibilities for authorized workers. • ENV112 Hazardous Waste & Env Management • RAD102 General Employee Radiological Training • EC100 Export Control Awareness Training • ELC901 Safe Switching Briefing • ELC106 R&D Electrical Safety <p>These courses are required training for all authorized "maintenance" workers.</p>
Resulting Hazards: <ul style="list-style-type: none"> • Electric Shock • Chemical Exposure • Hazardous Waste Disposal • Thermal burns • Implosion/Explosion (Pressure System) 	Mitigation of Identified Hazards: Maintenance workers must take the appropriate precautions while servicing lab equipment. When accessing areas where hazardous energies may be present, use LOTO procedures to prevent injury. Refer to the LOTO Notebook on top of the LOTO lock box located in IL chase 1513 for the equipment specific LOTO procedures. Wear the appropriate PPE for a given task, minimum protection required is lab coat, safety glasses and nitrile gloves. Some activities may require additional protection which may include a respirator, acid gloves or an acid apron. Please refer to the appropriate OP, PHS or area specific SWP for additional guidance on PPE requirements.

Continuous Improvement and Feedback

This SWP document must be reviewed, revised (if necessary), and re-signed at least annually in conjunction with PHS renewal. This SWP must be revised earlier in response to:

- new hazards (e.g. chemicals) being introduced in to the laboratory,
- recognition of hazards not previously considered, or
- identification of significant improvements to hazard control/mitigation defined in this document,

and other situations where improvement to laboratory safety should be documented. It should be noted that these same conditions may require revision of the laboratory PHS and required training matrix.

Reviews and Approval

Prepared by Laboratory Owner											
<u>John Nogan</u> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Printed Name Signature Date </div>											
Reviewed by CINT ES&H Coordinator											
<u>Wayne Davis</u> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Printed Name Signature Date </div>											
_____ Center ES&H Coordinator initials here designate that further review by Industrial Hygiene or other Subject Matter Experts is not required.											
Reviewed by Center Industrial Hygienist as required											
<u>Brad Lackey</u> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Printed Name Signature Date </div>											
Additional SME Review required by Center ES&H Coordinator or Department Manager											
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Approved by Department Manager By approving the SWP, the Department Manager attests that it is an appropriate assessment of the ES&H risks associated with the R&D activities that are authorized to take place in the designated lab(s). The approval signature further indicates that the hazard mitigations specified in this SWP are also appropriate.											
<u>Sean Hearne</u> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> Printed Name Signature Date </div>											

Authorized Worker Agreement:

Signature by the Authorized Workers in the following Summary Authorization Table certify that the worker has read, understood, and agree to follow the Safe Working Practices identified in this document. Authorized Workers agree that they will not introduce hazards into this laboratory that are not covered by the PHS, SWP, and related documents.”

If a new employee (e.g. student, post doc, etc) is brought in to work in the laboratory, their training must be evaluated by the manager prior to any work being assigned or conducted. Their signature asserts that this has been done.

Printed Name	Signature	Date	Lab Owner Confirm. (initials)	Chemical Operations	Toxic Gases	Pressure System Operations	Environmental	Thermal Hazards	Equipment Maintenance					

Rigor Level

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